Validation of LaRC-derived MODIS Cloud Properties Using the ARM SGP and NSA Measurements

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Outline

- (1) Data Source and Average methods
- (2) SGP, day & night, optically thick & thin cloud height and temperature
- (3) SGP, day & night single layer stratus, mid, and cirrus cloud microphysics
- (4) SGP, day & night multi-layer stratus and mid cloud microphysics
- (5) NSA, day optically thick & thin cloud height and temp; Single layer stratus and mid cloud microphysics
- (6) Conclusions

Part 1:Data Source and Average Methods

Data Source:

Surface: DOE ARM measurements and retrievals

Satellite: TERRA MODIS cloud properties

Location:

DOE ARM SGP Site: Oklahoma

DOE ARM NSA Site: North Slope Alaska

Time Period:

SGP Site: From Nov. 2000 to Dec. 2001

NSA Site: From April to Oct. 2000

Data Source at SGP site (Day)

	Surface	3km_wind_strip	30x30km ²
Total (cases)	119	119	106
Optically thin	43	43	36
Optically thick	76	76	70

Single layer Microphysics:

Stratus	21	21	18	
Mid	20	19	15	
Cirrus	19	19	17	

Multi-layer Microphysics:

Stratus	17	17	4
Mid	8	8	6

Data Source at SGP site (night)

	Surface	3km_wind_strip	$30x30km^2$
Total (cases)	121	119	105
Optically thin	61	59	47
Optically thick	60	60	58

Single-layer Microphysics:

Stratus	8	8	8
Mid	18	18	12
Cirrus	42	42	35

Multi-layer Microphysics:

Stratus	9	9	2
Mid	5	5	2

Data Source at NSA site (Day)

	Surface	3km_wind_strip	$30x30km^2$
Total (cases)	128	113	119
Optically thin	32	29	27
Optically thick	96	84	92

Single layer Microphysics:

Stratus	65	55	62
Mid	17	15	13
Cirrus	0	9	4

Surface and Satellite average methods

Surface:

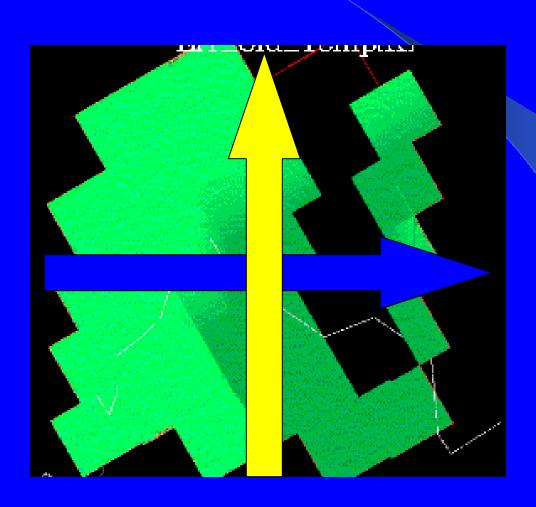
The surface data were averaged over an hour centered at the time of the TERRA overpass.

MODIS:

Method 1 (old): The MODIS cloud products were averaged in a 30-km x 30-km spatial resolution centered on the ARM SGP site.

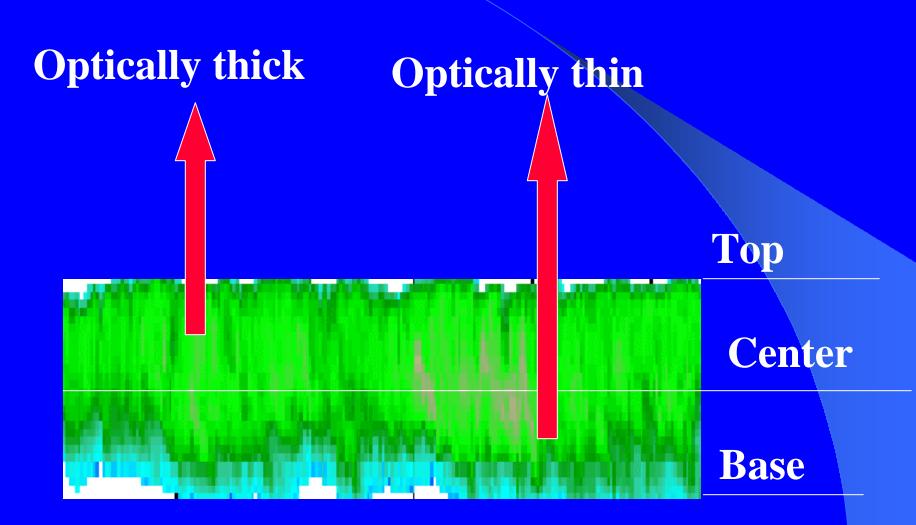
Method 2 (new): The MODIS cloud products were averaged along 3km wind strip over an hour centered at the time of the TERRA overpass based on ECMWF wind speed and direction.

What's difference between Methods 1 & 2

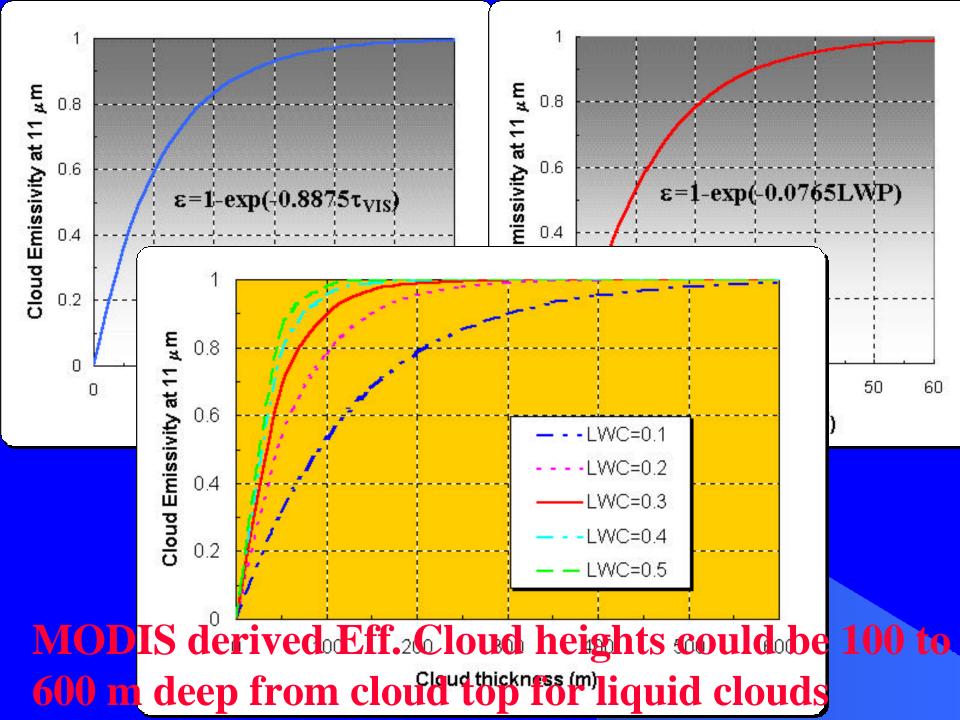


Part 2: SGP, day & night, optically thick & thin cloud height and temperature

What results do we expect to get from the cloud height comparison?

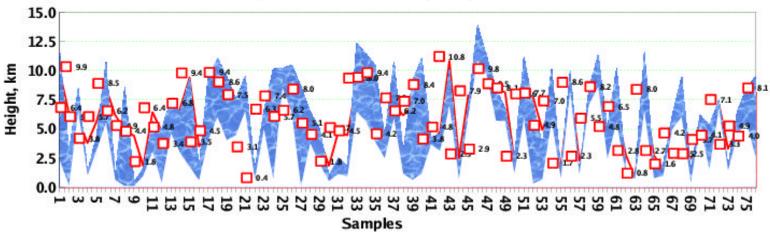


This is only the qualitative answer!



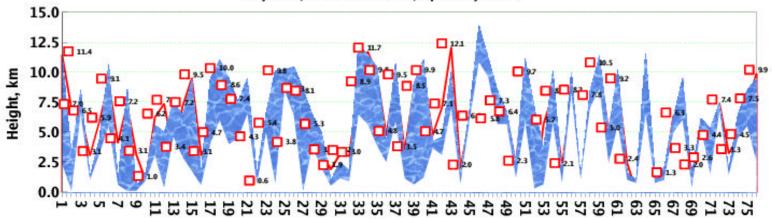
SFC_MODIS_SGP_Cloud_Height_3km Strip

daytime, 200011-200112, optically thick



SFC_MODIS_SGP_Cloud_Height_30x30km

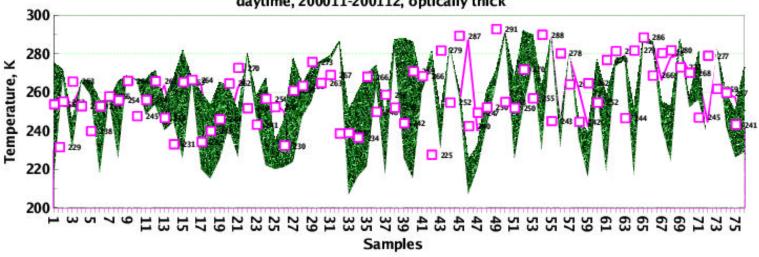
daytime, 200011-200112, optically thick



Most MODIS Eff. Cloud heights are between surface measured cloud center and top heights

SFC_MODIS_SGP_Cloud_Temp_3km Strip

daytime, 200011-200112, optically thick



SFC_MODIS_SGP_Cloud_Temp_30x30km daytime, 200011-200112, optically thick

Samples

300

280

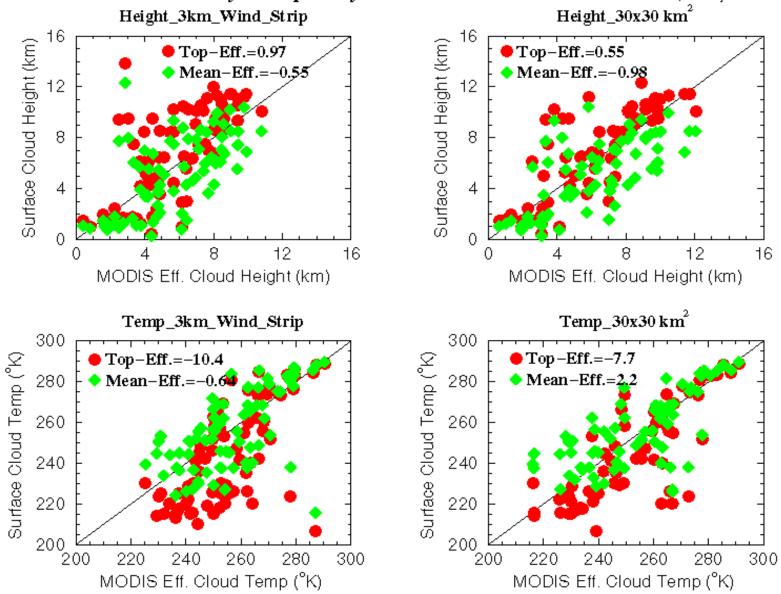
260

220

200

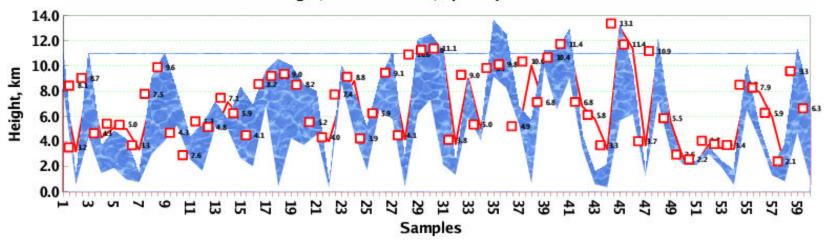
Temperature, K

Daytime optically thick clouds at the ARM SGP Site ($\tau > 5$)

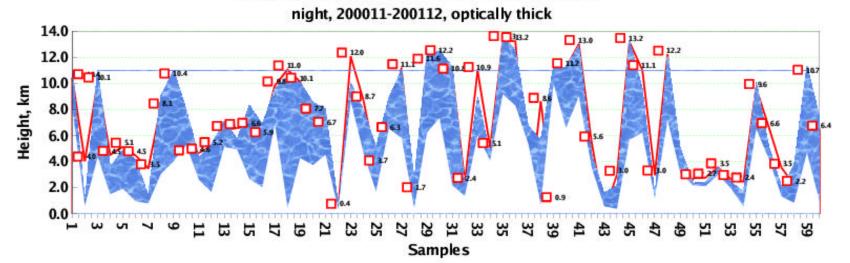


SFC_MODIS_SGP_Cloud_Height_3km Strip

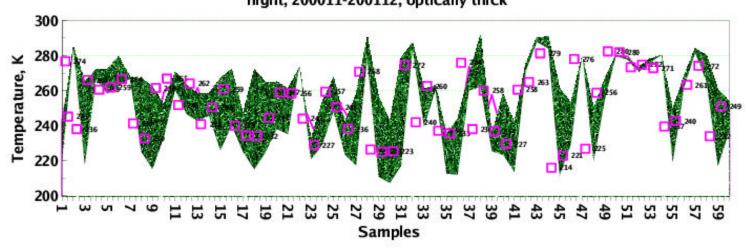
night, 200011-200112, optically thick



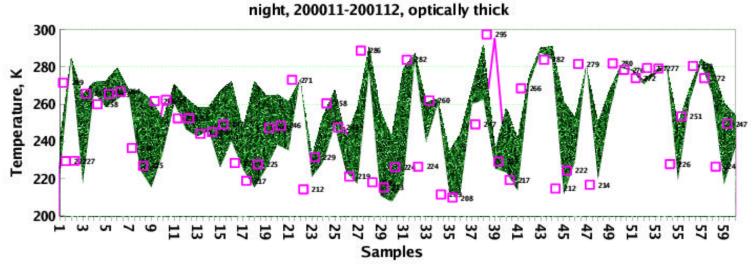
SFC_MODIS_SGP_Cloud_Height_30x30km

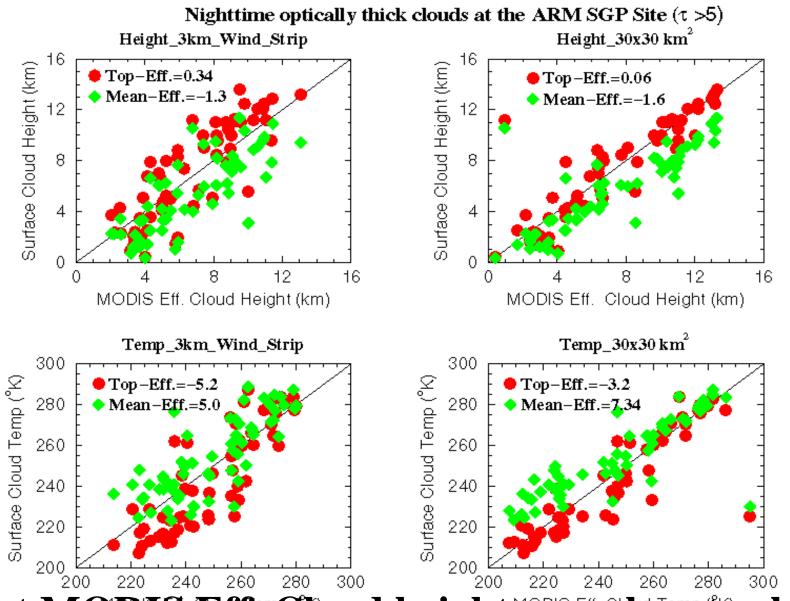


SFC_MODIS_SGP_Cloud_Temp_3km Strip night, 200011-200112, optically thick

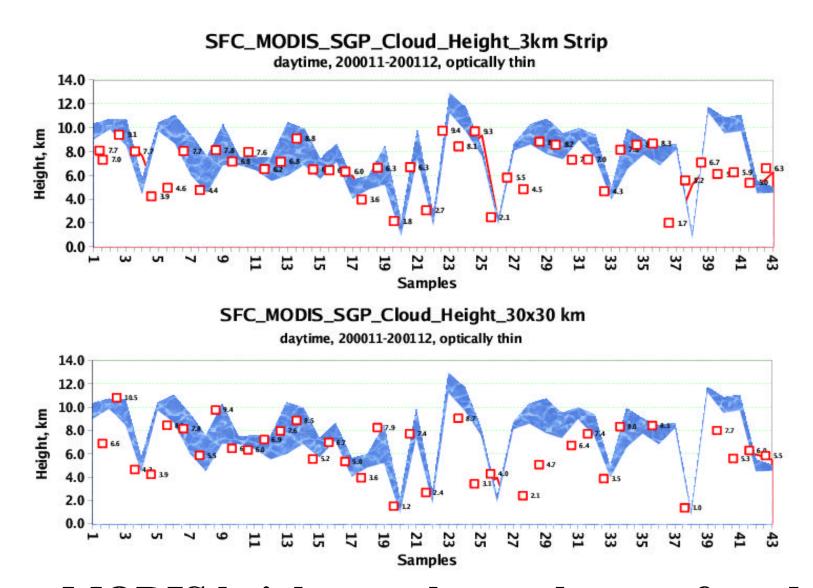


SFC_MODIS_SGP_Cloud_Temp_30x30km

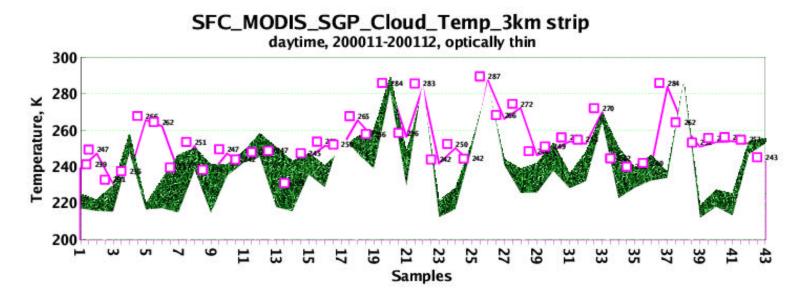


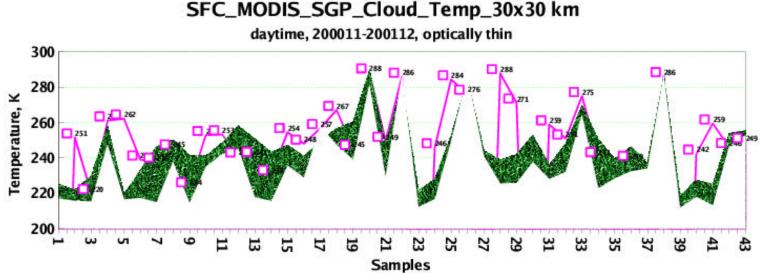


Night MODIS Eff. Cloud heights are close to cloud top related to the daytime comparison

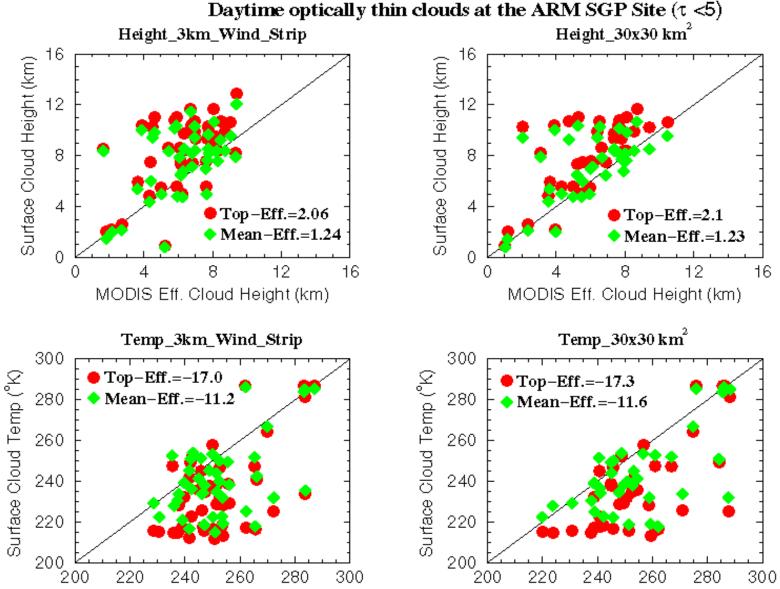


Most MODIS heights are lower than surface derived cloud center, some are lower than cloud base height.

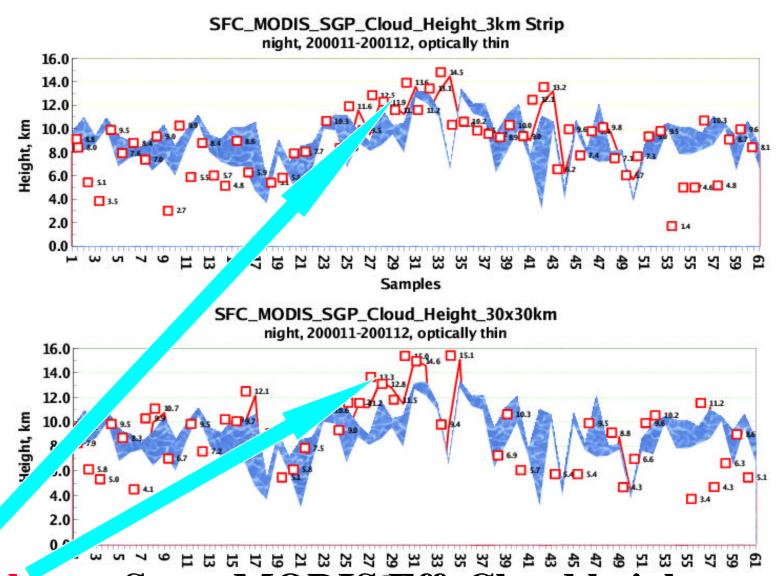




Most MODIS temps are higher than surface mean temps, some are higher than cloud base temp.

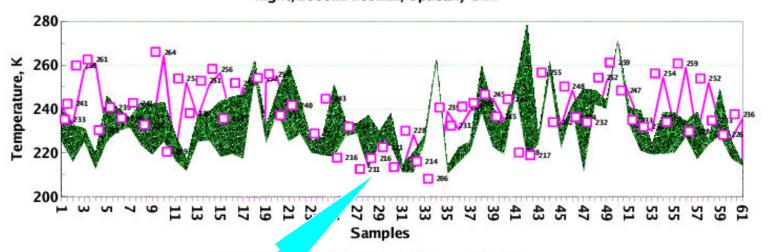


By average, MODIS Eff. Cloud height is about 1.2 km below surface derived cloud center.

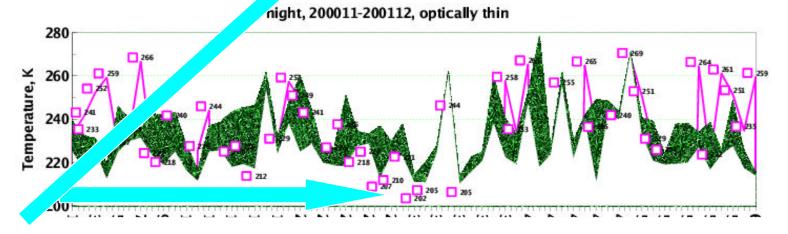


Problem: Some MODIS Eff. Cloud heights are higher than surface derived cloud top heights

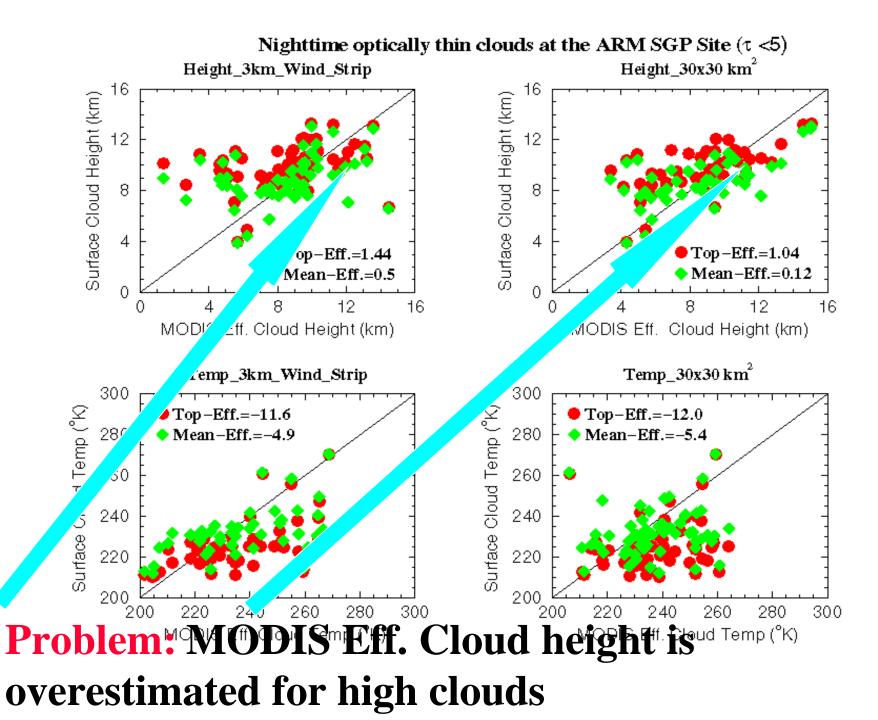
SFC_MODIS_SGP_Cloud_Temp_3km Strip night, 200011-200112, optically thin

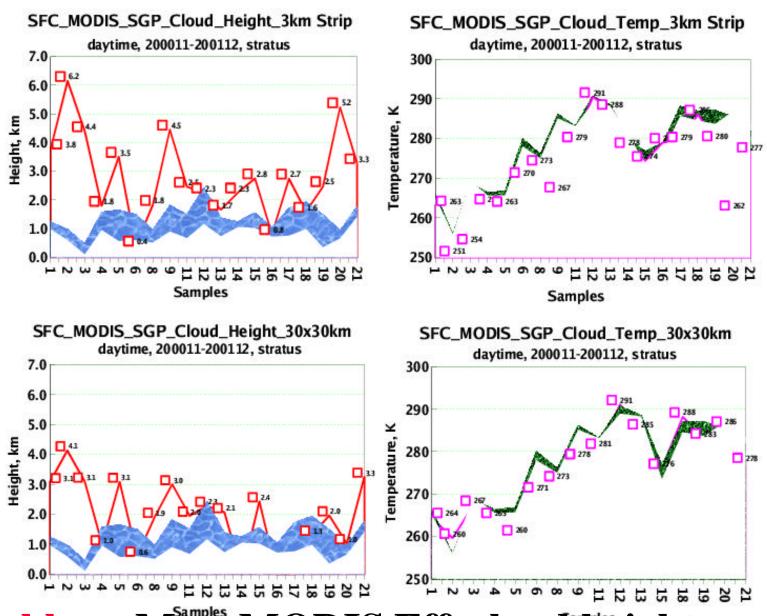


SFC_M__S_SGP_Cloud_Temp_30x30km

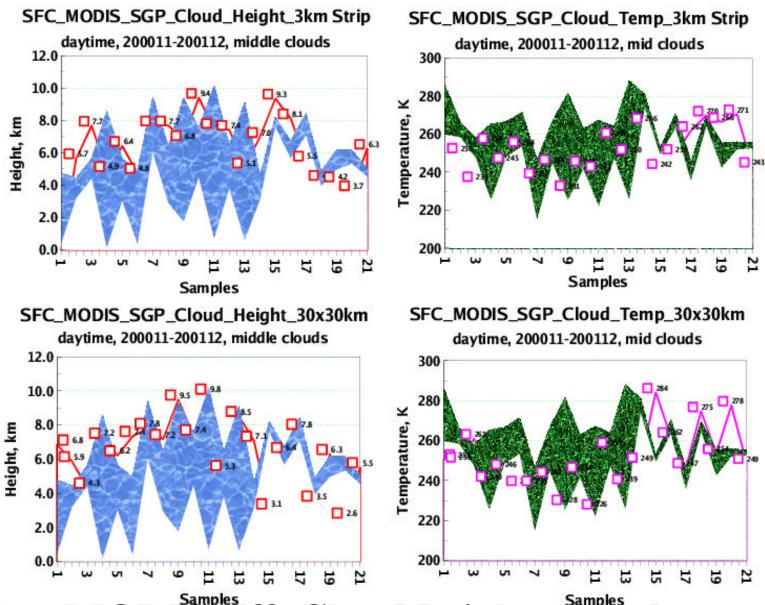


These lower MODIS Eff. Cloud temps are responsible for higher MODIS Eff. Cloud heights

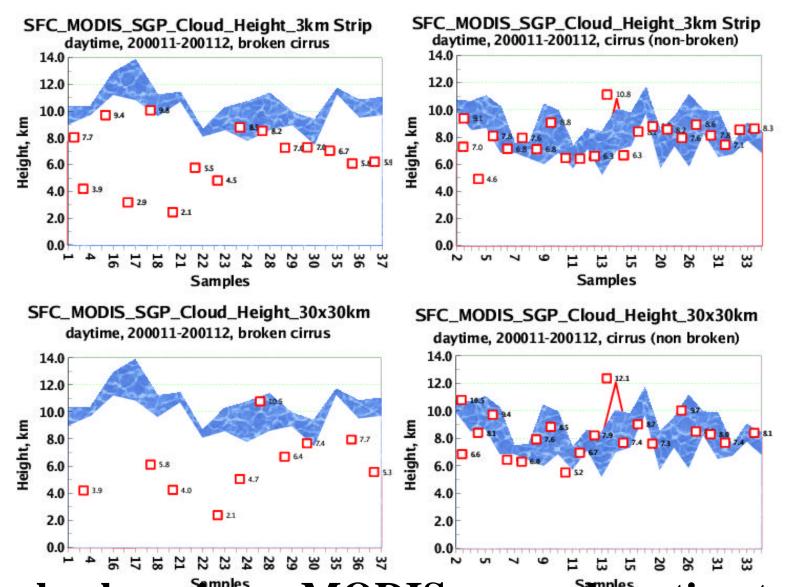




Problem: Most MODIS Eff. cloud heights are overestimated for stratus clouds.

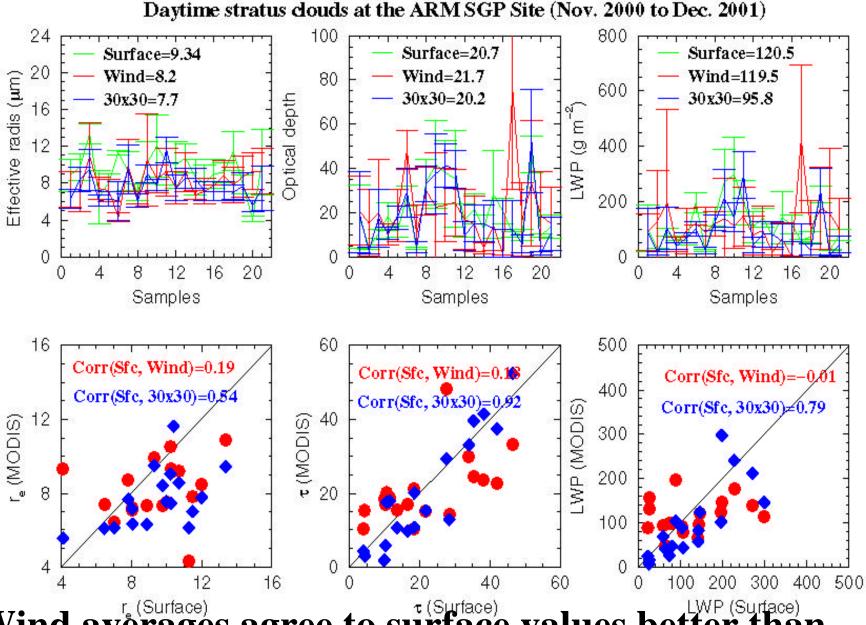


Most MODIS Eff. Cloud heights are close to cloud top height for Mid clouds.

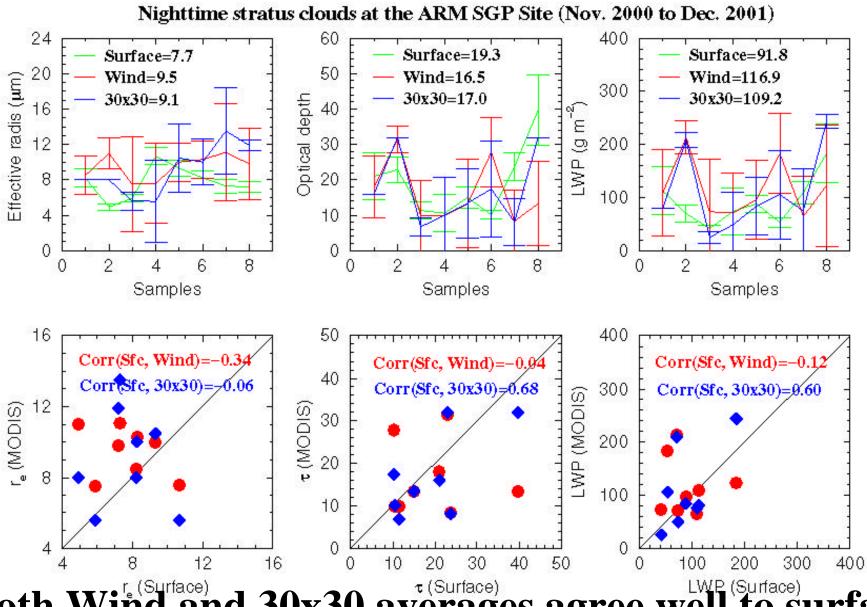


For broken cirrus: MODIS are underestimated For solid cirrus: MODIS agree well to surface

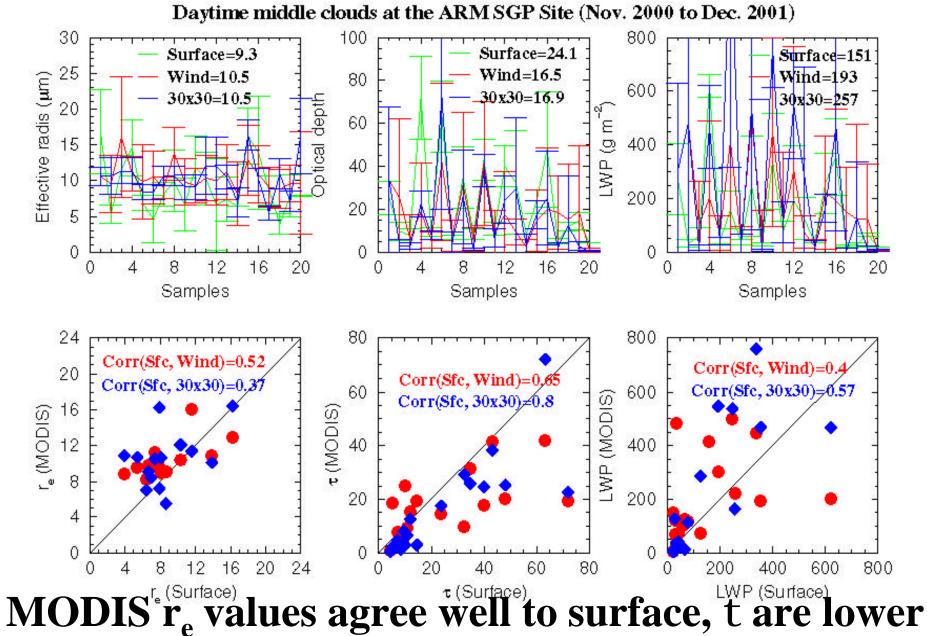
Part 3: SGP, day & night single layer stratus, mid, and cirrus cloud microphysics



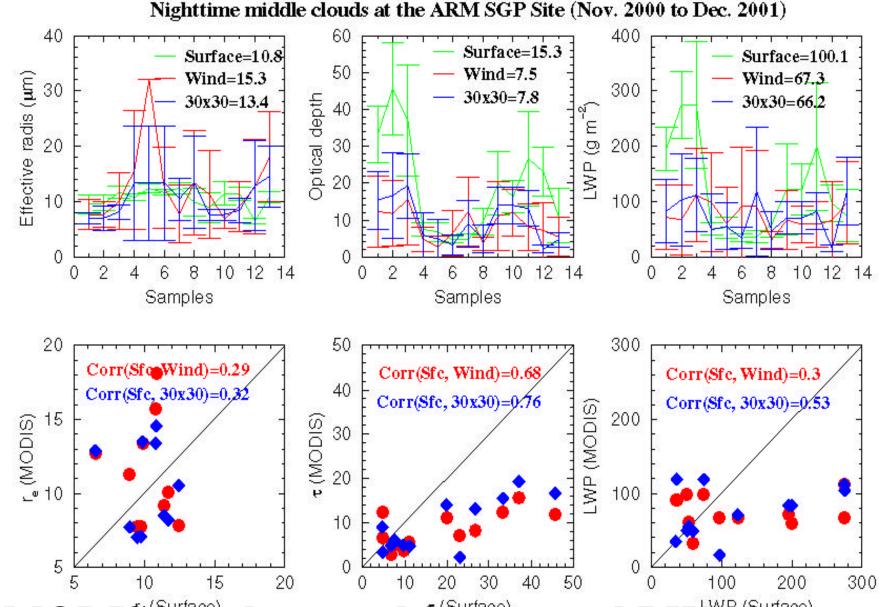
Wind averages agree to surface values better than $30x30~km^2$, BUT with much lower correlations



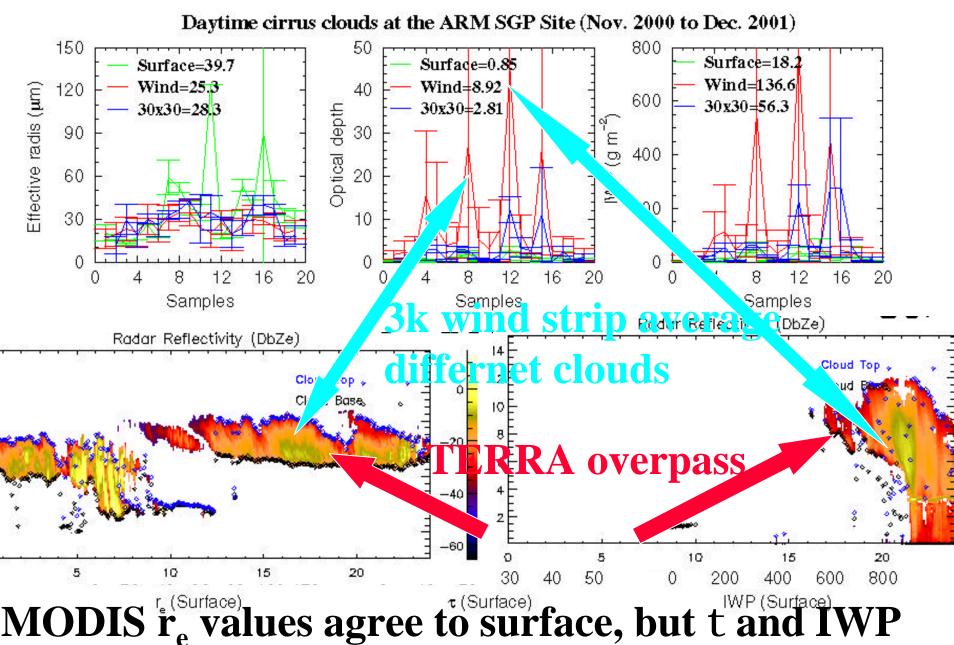
Both Wind and 30x30 averages agree well to surface values, BUT Wind have much lower correlations



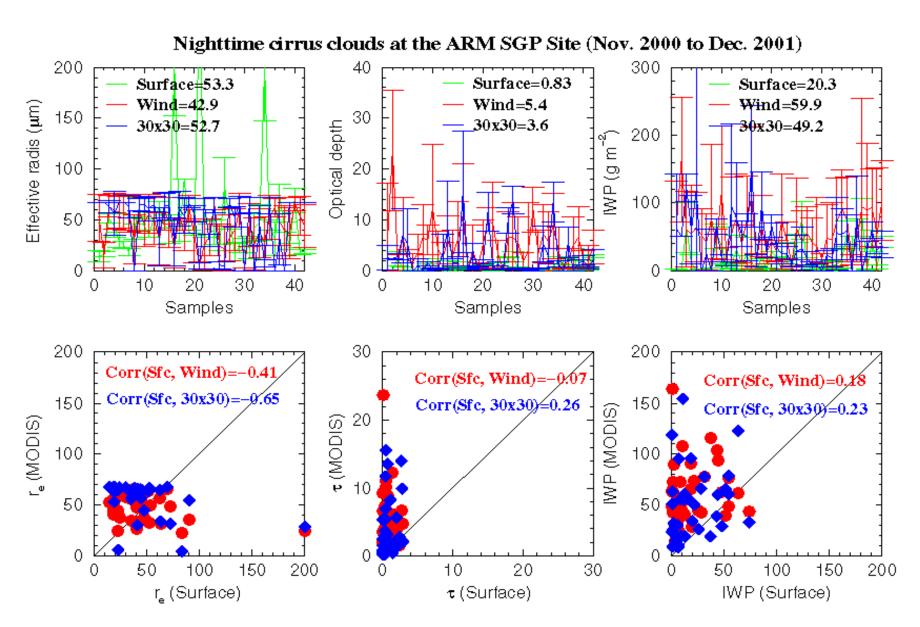
MODIS'r_e values agree well to surface, t are lower and LWPs are larger than surface with high corrs.



MODIS revalues are larger, t and LWP are smaller than surface, with high correlations.

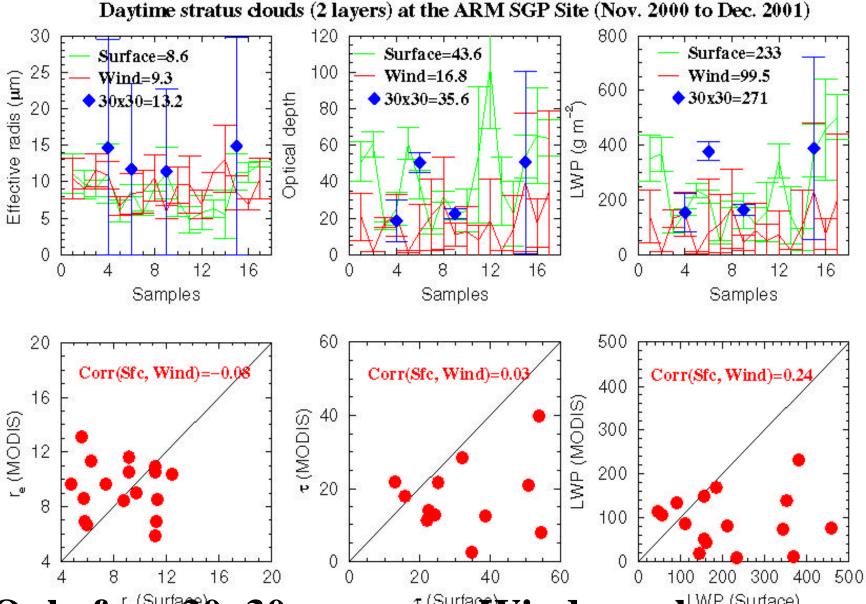


MODIS r_e values agree to surface, but t and IWP are much higher than surface, with fair correlations

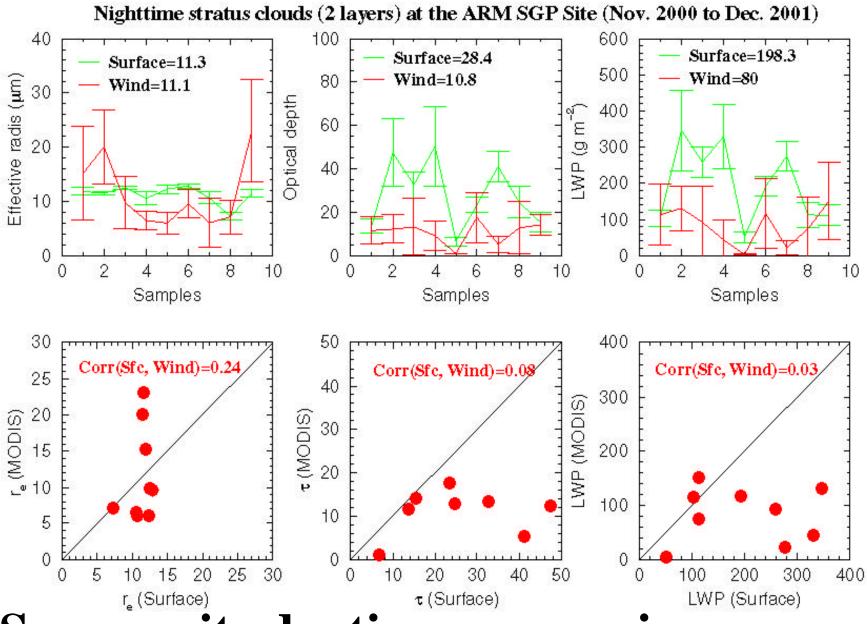


Same as its daytime counterpart

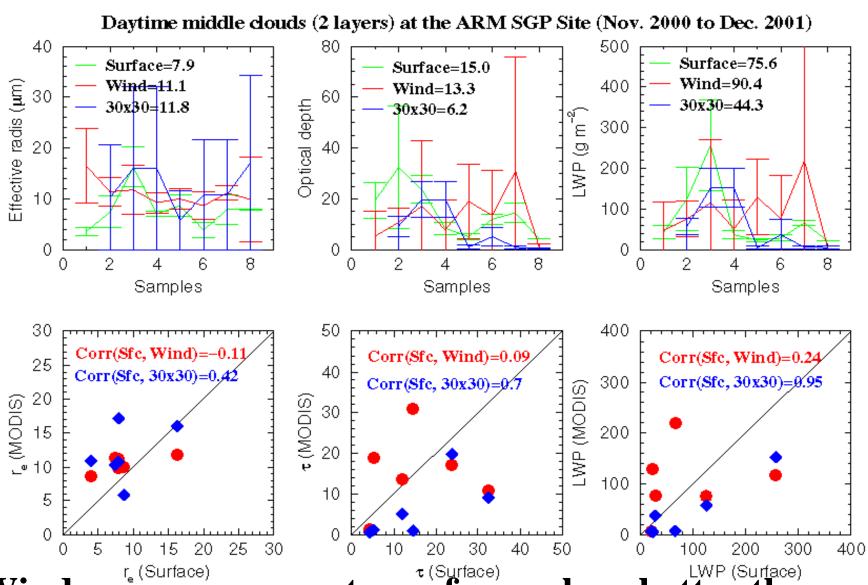
Part 4: SGP, day & night MULTI-layer stratus and mid cloud microphysics



Only four 30x30 averages. Wind r_e values agree well to surface, BUT t and LWP are much smaller



Same as its daytime comparison



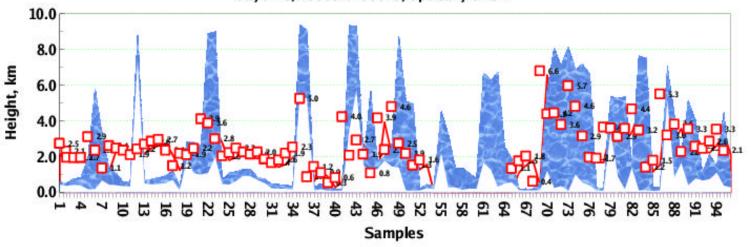
Wind averages agree to surface values better than 30x30 km, BUT with much lower correlations

Part 5: NSA, day optically thick & thin cloud height and temp.

Day, single-layer stratus and mid cloud microphysics

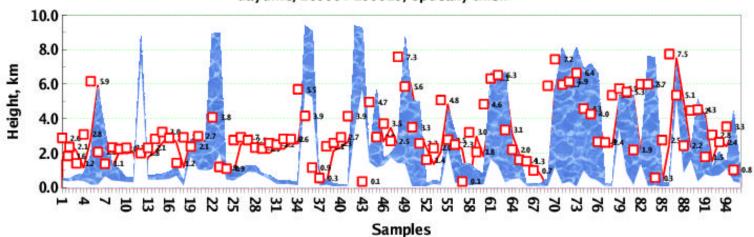
SFC_MODIS_NSA_Cloud_Height_3km Strip

daytime, 200004-200010, optically thick



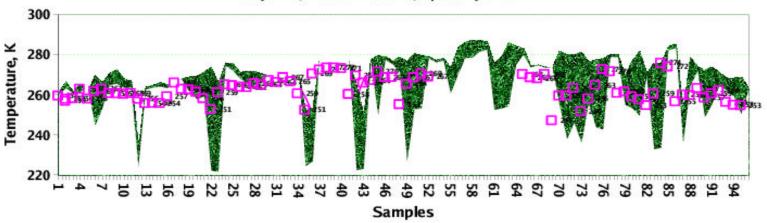
SFC_MODIS_NSA_Cloud_Height_30x30km

daytime, 200004-200010, optically thick



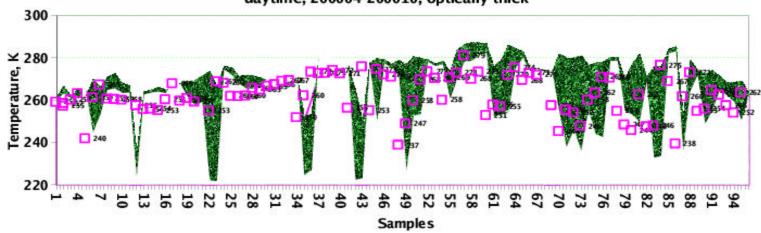
SFC_MODIS_NSA_Cloud_Temp_3km Strip

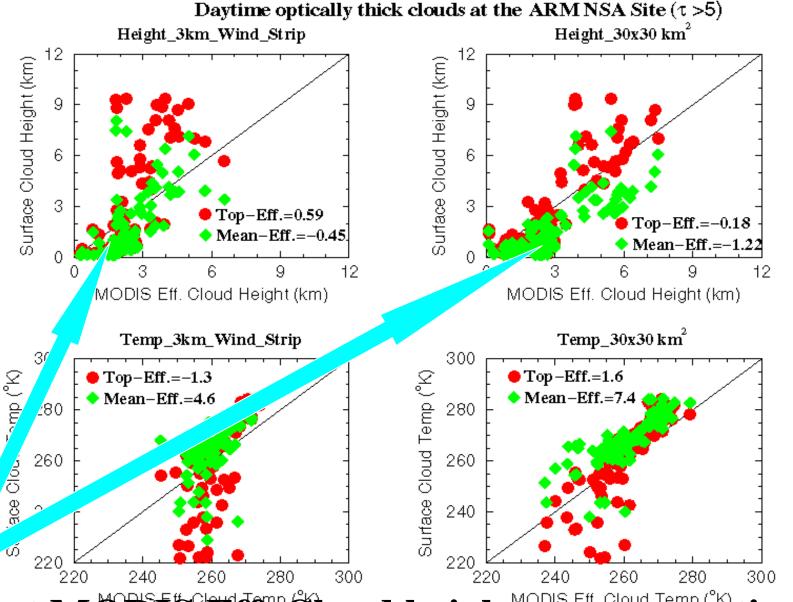
daytime, 200004-200010, optically thick



SFC_MODIS_NSA_Cloud_Height_30x30km

daytime, 200004-200010, optically thick

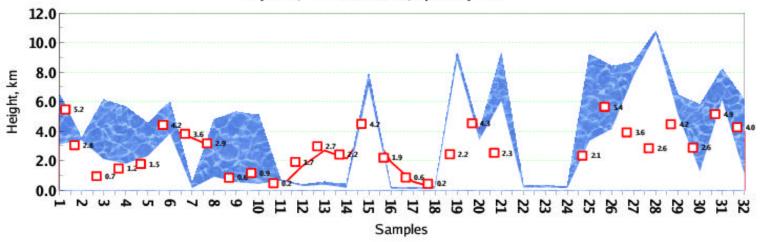




Most MODIS Eff. Cloud heights are overestimated for low clouds, and reasonable for high clouds.

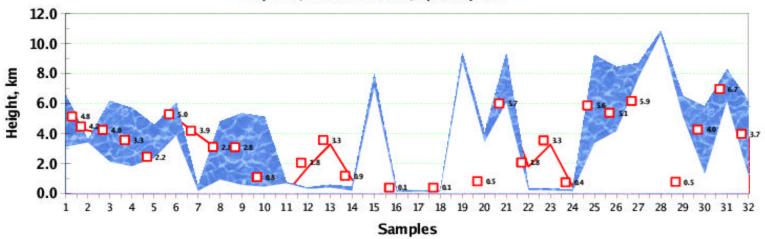
SFC_MODIS_NSA_Cloud_Height_3km Strip

daytime, 200004-200010, optically thin



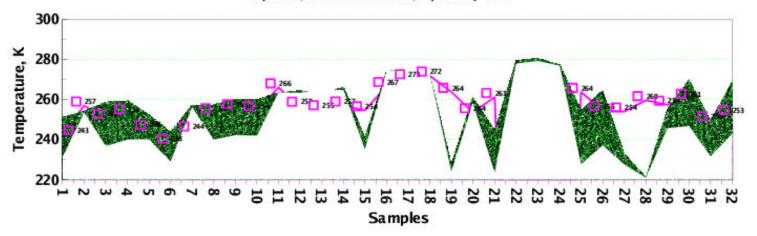
SFC_MODIS_NSA_Cloud_Height_30x30km

daytime, 200004-200010, optically thin



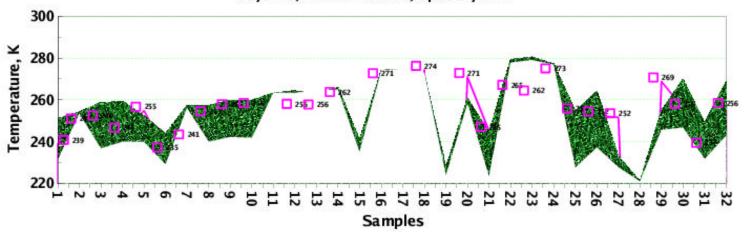
SFC_MODIS_NSA_Cloud_Temp_3km Strip

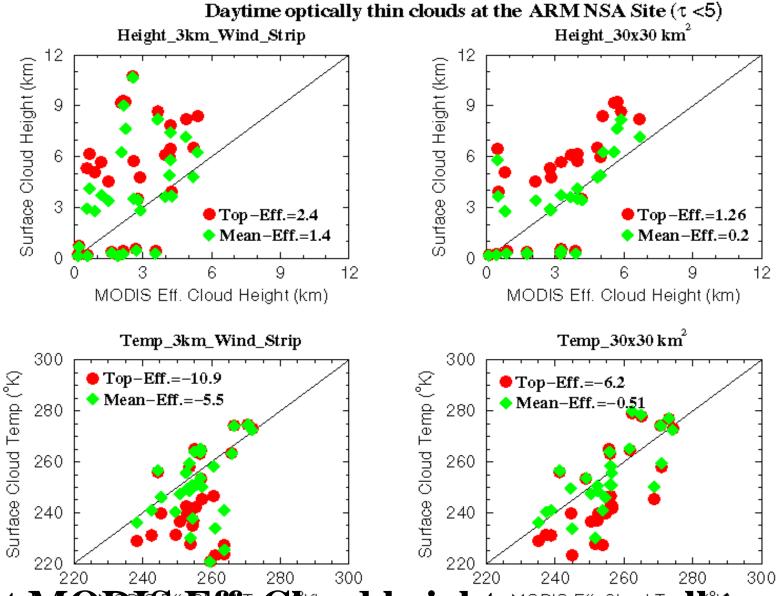
daytime, 200004-200010, optically thin



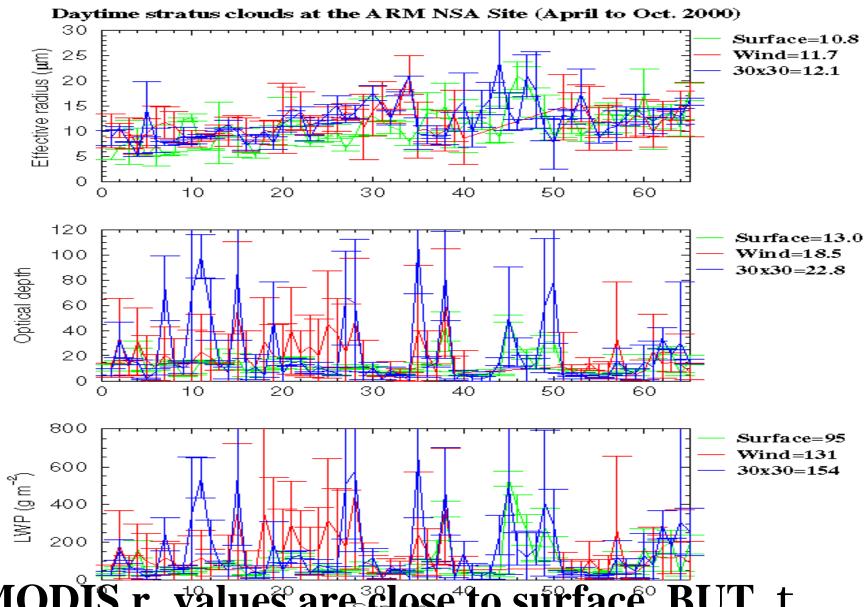
SFC_MODIS_NSA_Cloud_Temp_30x30km

daytime, 200004-200010, optically thin



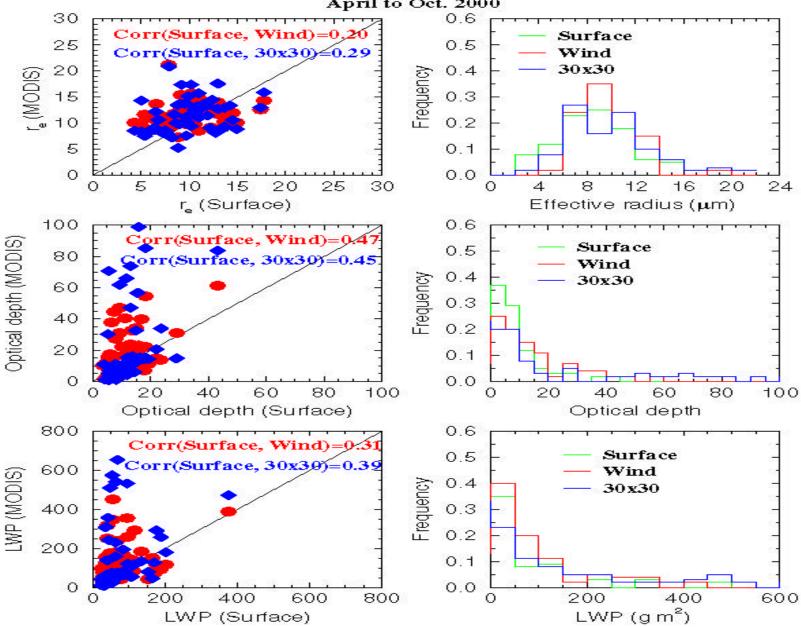


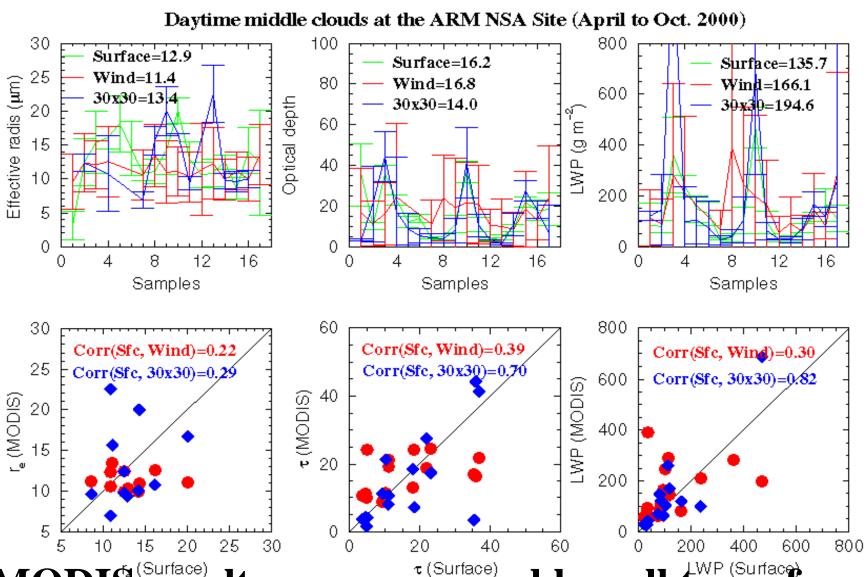
Most MODISTERT. Cloud heights agree well to surface measurement EXCEPT a few low cases



MODIS r_e values are close to surface, BUT t and LWP are higher than surface

Daytime stratus clouds at the ARM NSA Site April to Oct. 2000





MODIS results agree reasonable well to surface. Again, 30x30 have higher correlations than Wind

Conclusions

- 1. 3km Wind strips can detect more cloud cases than 30x30 km² box if surface measurements are baseline.
- 2. Both Wind strip and 30x30 Eff. Cloud heights are within surface measured cloud boundaries (day/night, optically thick/thin).
- **Based on cloud types:**
- Good agreement for solid cirrus and mid clouds.
- **Problem:** MODIS Eff. Cloud heights are overestimated for low clouds, and underestimated for broken cirrus.
- 3. For low and mid ms, Wind averages agree to surface values better than 30x30 km, BUT with much lower corrs. For cirrus ms, MODIS r_e values agree to surface, but t and IWP are much higher than surface, with fair correlations

Conclusion (cont)

- 4. MULTI-layer clouds
- For stratus ms, Wind r_e values agree well to surface, BUT t and LWP are much smaller than surface
- For Mid ms, Wind averages agree well to surface values than 30x30 km, BUT with much lower corr.
- 5. NSA Site height/temp and microphysics
- Most optically thin and thick higher cloud height and temp, MODIS results agree well to surface.
- For low cloud height and temp, most MODIS Eff. Cloud
- heights are overestimated, same as its SGP comparison.
- For stratus ms, MODIS r_e are close to surface, BUT t and LWP are higher than surface.
- For Mid ms, MODIS results agree reasonable well to surface. Again, 30x30 have higher correlations than Wind

